A REPORT OF HURRICANES, AND CONDITIONS INDICATING A HURRICANE, IN THE VICINITY OF GALVESTON, TEXAS, FROM 1867 to 1916.

TO

MR.DAVID DALY

MANAGER

GALVESTON-HOUSTON ELECTRIC RAILWAY COMPANY

MARCH 7, 1916.

BY REX DUNBAR FRAZIER

Pursuant with your request for a list of hurricanes that have visited Galveston during the past fifty years the following has been compiled from all available records of Galveston's weather. These included what histories could be obtained in the public libraries of Galveston and Houston and the weather records in possession of the United States Weather Bureau. The latter consists mostly of a dozen hand written volumes dating from April 19, 1871, when the weather office was established in Galveston under the supervision of the Signal Corps of the Unites States Army.

Reporting and chronicling weather conditions in the early days had not been systematized as it is today. There were few reporting stations, few, if any, cable stations in the West Indies and the methods of forecasting and recording weather conditions were so different from the methods of today that at times it is difficult to determine what was and what wasn't a hurricane. Of course, when a hurricane passed close to Galveston, causing considerable damage from wind and water, this difficulty was not encountered. But when a hurricane passed inland far down or far up the coast, or a hundred miles or so to the eastward, then it is difficult to tell from these early reports whether it was indeed a hurricane or a "low" in the Gulf or at some section of the upper or lower coast.

These early records were in the form of daily journals, handwritten in ink, and in many cases were almost illegible.

Many of them merely carried entries such as: "Weather fair, clear sunset," as contrasted with the later typewritten records of half a page or more for each day. It is possible that hurricanes of small area might have passed inland near Galveston, or near the city in the Gulf, which the weather office would have no records of. Should they have entered the coast at some portion remote from towns or habitations of course no opportunity would be offered for their observation. Likewise, if passing close to the city in the Gulf, on account of the meagre outside reports received, their proximity could not be determined from local observations, or at least their influence on the weather would not have differed from that caused by a passing "low."

A hurricane of small area might pass inland either below or above Galveston, and while it might not cause greater than a gale and a fair tide in the city, which would be entered in the weather records, it might cause serious wind damage and a considerable tide a few miles from the city. The 1909 storm is an illustration. Several months ago Professor E. H. Bowie, now district forecaster in the Washington office, but observer at Galveston for a few years after the 1900 storm, told the writer that during 1902, two typical hurricanes of very small area, probably not more than fifteen or twenty miles in diameter, passed inland below Galveston. The wind velocities in these storms probably were as great as in a hurricane of much larger area and they carried a high tide where they struck the coast, but as they either passed across the Gulf without being observed by any

reporting vessel, or originated in the western Gulf, they were not reported as hurricanes. Striking the coast, where they did, at points where there were no towns or reporting stations, they are not included in the list of hurricanes in Weather Bureau Bulletins. Yet Professor Bowie stated they were typical hurricanes and if they had struck some coast town evidently would have done considerable damage. As a storm of this area might seriously damage the Interurban, should it pass inland just West of Galveston, there is included in this report those journal entries that seem to indicate the near presence of a tropical storm. This will assist in giving an idea of the number of disturbances of this character that have visited the western Gulf. Also, those hurricanes that are chronicled in Professor Fassig's bulletin, "Hurricanes of the West Indies," are described in detail that you may gain an idea of the extent of damage possible to Galveston and vicinity when a hurricane of wide area passes at some distance from the city, or enters the land at some point quite a distance above or below Galveston.

For the benefit of those, into whose hands this may fall, who are not familiar with that type of storm generally known as the West Indian Hurricane, it may be well to briefly give their theoretical origin, the point of origin, probable path and some of their characteristics. There are three accepted theories as to their origin. One, the convectional theory is: in a large mass of quiet, warm, moist air suppose some portion of it should

become more heated than that surrounding. It would rise, expand, grow cooler, reach its dew point and probably yield precipitation. The latent heat liberated by the condensation of the water vapor into cloud and rain would lessen the rate of cooling of the rising air and cause still further rise. Due to the excess of temperature and moisture the pressure in this area would be slightly less than in surrounding regions, which would tend to cause a still further rise by the outside air rushing in to replace the lighter air. This cooler air would be deflected to the right, in the northern hemisphere, by the earth's rotation and would approach the center in a counterclockwise turning spiral. This rotation of the air about the center would cause centrifugal force, which would hold the air away from the center, thus causing a still lower barometric pressure. This increased difference in pressure between the center and surrounding regions would drive in the air with greater vigor and cause a further rise of air in the center. This would cause more clouds, more precipitation, more latent heat to be liberated and a still more vigorous rise. This in turn would cause still more air to come toward the center, which would make the whirl still more vigorous, causing more centrifugal force and a still lower barometric pressure in the center. This becomes greater and greater until a hurricane is the result.

So long as the hurricane is supplied with a volume of warm, moist air it will continue to increase in intensity. But as soon as this supply is cut off, as in the case where it has

passed inland, the air would cease to rise as rapidly and the general lowering of the temperature would cause the moisture contained to be rapidly precipitated.

Another theory is based on the general distribution of pressure overlying the Atlantic ocean North and South of the Equator during the hurricane season, and the general wind movements which they cause.

Overlying the North Atlantic ocean is a permanent area of high pressure during the summer months, from which the winds blow clockwise. This causes the northeast trade winds between the northern horse latitudes and the Equator. The lengthening of these winds during the northern summer and the passing of the southeast trades from the South Atlantic across the Equator, when they become southwest winds, because of the deflection caused by the earth's rotation, are supposed to form ideal conditions in the doldrums for the birth of a hurricane. The meeting of these adverse air currents, the one northeast and the other southwest are supposed to produce gyratory motions of the atmosphere and a hurricane is formed.

The later, and generally accepted theory, is a combination of these two.

When a hurricane is fully formed it is a vast atmospheric whirl, turning counterclockwise in the northern hemisphere and clockwise in the southern, with spirally inflowing winds which nearly always attain destructive velocities. Its whole formation may be from fifteen or twenty miles in width to several hundred,

although it might be difficult to differentiate between the smaller storm and a tornado, despite the fact that the latter is usually confined to a very small area. Some hurricanes have been reported as having a width of a thousand miles and to have taken ten days in passing a given point. A hurricane 300 to 600 miles in diameter would have a calm, central eye fifteen to twenty miles in diameter. The lowest barometric pressure in a hurricane is probably about 28 inches, although a pressure of 27.15 inches has been recorded. The wind velocity is small in the outer area, nothing in the calm, central eye, and at its greatest velocity in the central rain area. The maximum velocity nearly always reaches 100 miles per hour and sometimes probably 200 miles per hour. When approaching Galveston from the southeast or south the south, southeast, east and northeast winds are the most dangerous.

Besides the terrific velocities of the inflowing winds the entire area of a hurricane has a progressive movement of from 6 to 12 miles per hour.

Hurricanes occur in the summer and fall months only, when the heat equator is well north of the geographical equator, and are almost wholly confined within an area lying between 12 and 26 north, and 56 and 90 west, Greenwich. However, a few hurricanes have originated, or at least have first been reported, from points slightly west and north of this area.

The point of origin is supposedly near the Windward Islands, but is probably much farther east than that. A typical

hurricane path is in the form of a parabola, and ordinarily a hurricane travels westerly or northwesterly either immediately above or below the West Indies, turning and following a northerly path at about 25 north and recurving northeasterly at about 30 north. Professor Fassig has charted mean paths of hurricanes for the different months of the hurricane season, but they have little value. Hurricanes are almost as eccentric in their movements as any other form of violent cyclone, and general rules only can apply to their movements. It is generally believed that the position of the "highs" and "lows" over the United States determine their course.

Professor Bowie, in charting the probable daily movements, based upon the average daily movements of recorded hurricanes, offers the best means for determining the possible path of an existing hurricane.

Hurricanes have no periodicy. They are apt to occur with marked frequency in some years and in others be reported absent from the Gulf. There has been recorded as many as eleven hurricanes in one year. Some years have occured when none was recorded. It is the personal opinion of the writer that no year passes but that a storm of hurricane type is generated in the Gulf or Caribbean.

Galveston is not in or near the mean paths as laid down by Professor Fassig, and their advent into the western Gulf and against the Texas coast is unusual. However, one may confidently look for a recurrence of the disastrous hurricanes

that have reached the Texas coast without being able to predict when or how often they may occur. The history of Galveston and its weather bureau records show that it has been subjected to inundation and damage from hurricanes at frequent intervals within the memory of man. Several times within the past fifty years the centers of hurricanes have passed very close to the city, causing damage to property, loss of lives and scouring of the beach from wave action. Some of these storms which have passed inland might have been as disastrous as the 1900 catastrophe had they struck a populous district.

The people of the city always have been in fear of hurricanes and consequent inundation. In the earliest records of the weather office, early in the seventies, entries show that the people were as much concerned as today at the approach of a storm. After each hurricane had passed, no matter what the damage, they were equally as concerned in recovering what property they had left, rebuilding and repairing the damage done, and resuming their normal trend of living. Refuting expressions that Galveston may someday be abandoned it is the opinion of the writer, that inasmuch as other portions of the Gulf Coast are more frequently subjected to hurricanes and hurricane damage than Galveston and vicinity, that Galveston never will be abandoned unless the city should be totally destroyed as in the case of Indianola, Saluria, Bagdad and Clarksville on the Texas coast. It is doubtful if a hurricane could accomplish such destruction in the case of Galveston because

of its seawall and its substantial structures, knowing the approximate strength of hurricane winds and the probable height the Gulf would attain during a hurricane.

Galveston weather office journal entries have been closely followed and freely quoted. The object has been to make the report accurate, and give enough data so that it can be better understood if scanned by one versed in meterology. Also, to give you the attitude of the people when threatening weather conditions exist, and to supply as much information as possible that might have a bearing upon the future of the Interurban and other Stone & Webster properties in the vicinity of Galveston.

There has been included tornadoes and waterspouts. These are purely local, but the latter are of frequent occurrence and one striking a soft portion of the Interurban roadbed, such as in the vicinity of Oyster, might materially damage it.

Data has been obtained from the journals above mentioned; records obtained in the Galveston Rosenberg library and the Houston Carnegie library; the Houston office of the United States Weather Bureau; Weather Bureau Bulletin X, by Oliver L. Fassig, Professor of Meterology, United States Weather Bureau; translations from works by Rev. Benito Vines, for many years director of the Havana Observatory, and various records and works on meterology.

The writer is indebted to Professor E. H. Bowie, District Forecaster, United States Weather Bureau, Dr. B. Bunnemeyer, Director of the Eighth Climatological Section, United States Weather Bureau and W. P. Stewart, local forecaster in charge of the Galveston Weather office, United States Weather Bureau, for

information and data supplied.

In 1867 the Texas coast was swept by a terrific hurricane which caused considerable loss of life and damage in Galveston and vicinity. As the weather bureau had not been organized at that time and it seems no one took the trouble to make a record of this storm with any degree of accuracy the only records of it are brief paragraphs in histories and some of the later weather records. From available data it was probably of the same intensity as the 1875, 1886, 1900 and 1915 storms.

Between the dates of June 1 and June 4, 1871, evidently a hurricane passed in the vicinity of Galveston.

On June 1, the journal records that the barometer was falling with a light northeast wind and on June 2, mention was made of an exceptionally heavy sea.

On June 3, the barometer at 7 A.M. was 29.61 and at 4 P.M. the wind attained a velocity of 38 miles from the east, shifting to northeast at 4:36 P.M. with a continued velocity of 28 miles per hour. The rainfall amounted to 3 inches and on June 4, the barometer stood at 29.51 inches. This is practically the entire record for this period.

On June 8, of the same year, there is another entry of the barometer falling with the wind northeast 10 miles. On the following day there was a heavy sea with the barometer 29.53 and a maximum wind of 49 miles per hour from the northeast at 4:30 P.M. which destroyed all weather instruments on the roof. The wind attained an estimated velocity of 60 miles per hour.

On June 10, the journal contained the meagre entry "Barometer rising". Without doubt this was a hurricane that entered the coast close below Galveston or passed in the Gulf in the vicinity of the city.

On July 14, 1874, a waterspout was observed one mile off of the south beach of the city, which passed inland and broke when it reached the sand. Another waterspout was reported out to sea at the same time.

On September 3, 1874, storm warnings were received at the Galveston office and on September 5, an unusually high tide was recorded with the wind east, and the journal makes mention ofthe fact that the people were apprehensive of an overflow.

On September 6, the journal bears entry that there was considerable excitement in the city over the dread of an overflow from the unusually high tide that prevailed, but the danger passed with little damage to the city.

September 14, 1875, the barometer was reported falling, with a brisk wind from the northeast.

September 15, the barometer continued falling rapidly with a wind northeast which attained a velocity of 41 miles per hour at 9:30 P.M.

September 16, the barometer continued to fall and at 9:49 P.M. had fallen to 29.40. The wind continued from the northeast with velocities varying from 33 to 36 miles per hour.

September 17, the barometer fell to 29.03 at 2 P.M.

with a 40 mile wind, which blew away the anemometer and other weather instruments. A new anemometer was put up which recorded a wind of 60 miles when it was again blown away. The entire Island was covered with water and the center of the hurricane evidently passed very near the city. During the day of the 17th the wind suddenly shifted to the southeast and south and according to old residents that were interviewed, the water from the bay swept away several blocks of land from the east end of the island.

The center of this hurricane passed below Galveston and did considerable damage to points on the lower coast. The town of Indianola, on Matagorda Bay below Port Lavaca, was practically swept away. One hundred and seventy-six people were killed and three-fourths of the houses and buildings were washed away. The maximum wind registered at this point was 88 miles per hour when the weather observatory was destroyed and the observer killed. The estimated velocity was above 100 miles per hour. The damage in the vicinity of Indianola was estimated at more than $1,000,000.00.

On October 19, 1876, a hurricane was reported in the Gulf just east of Galveston, moving in a westerly direction. Galveston had a 24 mile wind with a fair tide, but on the following day the hurricane recurved and passed eastward.

On April 24, 1877, a twister lasting 15 minutes, with a wind velocity of 72 miles per hour from the north sunk several vessels in the channel and damaged the city to the extent of $50,000.00.

On September 16, 1877, a rain commenced, with strong northeasterly winds and a falling barometer accompanied by a heavy sea, causing the tide to rise much above its usual height. The journal bears entry that the weather was very thick overhead and indications pointed to an approaching tropical cyclone. Several vessels left their positions at the wharves and anchored in the roads for greater safety. Telegrams from New Orleans confirmed the apprehensions of Galvestonians and the hurricane was located somewhere in the Gulf south of Texas. Hurricane signals were ordered up and half hourly observations were commenced at 11:30 P.M. The journal states that the foul weather sunset prediction of the previous day was verified, which illustrates the method of forecasting weather in those days.

On September 17, the storm was increasing with a heavy gale from the northeast accompanied by rain. The barometer was falling steadily and the heavy sea which was still running caused an unusually high tide which overflowed many of the wharves and streets of the city. The journal states that the office was crowded with anxious inquirers and that half hourly observations continued throughout the day and night. The barometer reached its lowest point 29.48 at 1 P.M. and again at 2:45 P.M., with a northeast wind which attained its maximum velocity of 60 miles per hour at 6:45 from the north- northeast. The journal further states that from this time the wind gradually backed to north, reaching that point at 11:30 P.M. The hurricane caused great damage to the city, shipping and railroads in the vicinity, the

damages probably amounting to $100,000.00. But three fatalities ~~casualties~~ were reported.

On October 1 and 2 of the same year a storm passed in the vicinity of Galveston causing a very high tide and strong easterly and northeasterly winds backing to westerly. It is impossible to determine whether or not this was a hurricane or a "low" in the Gulf.

On December 3, 1877, a brisk southeast wind with cloudy and rainy weather caused a heavy surf and high tide on the Gulf side of the island, which was reported to be within 9 inches of the highest point attained during the hurricane of the previous September. The schooner "Two Sisters", about 30 tons, foundered in the Gulf a few miles east of Galveston about 4 A.M. This was probably ~~merely~~ a strong "low".

On February 26, 1878, the city experienced a gale from the east which commenced at 10 A.M. and lasted until 1:15 P.M. The gale caused unusually high tides on the Gulf and bay shores and did some damage to the lower portions of the city. This also was a strong "low".

On August 21, 1879, the barometer was reported falling with a wind northeast changing to east, with a high tide on the Gulf and bay shores.

On August 22, the wind changed from northeast to north and then northwest, the maximum velocity being 38 miles per hour. The storm caused considerable apprehension among the residents of Galveston and vicinity, the weather office being

thronged throughout the day and until a late hour of the night by anxious inquirers. Little damage was done to the city although the Western Union Telegraph lines were down for a few hours and the schooner "Lizzie", in quarantine, was sent aground.

This was the hurricane of August 20-24, which had its point of origin, or at least was first reported, in the vicinity of latitude 18° north and longitude 88° west. It crossed the Yucatan Peninsula and approached Galveston in a direct line, passing inland at a point about midway between Galveston and Port Arthur.

On August 12, 1880, the weather records of Galveston record that ships in the harbor commenced dragging their anchors and several put to sea or went up the bay to safety. The tide on the Gulf side was very high and carried away or dismantled many bath houses.

This was the hurricane of August 7-13, 1880, which originated in the vicinity of 14° north and 79° west. It passed northwestward crossing the tip of the Yucatan Peninsula and entered the lower Texas coast. Practically the entire coast of Texas was affected and many people were killed and many vessels were wrecked.

September 15, 1885, rain commenced to fall at 2:40 A.M. with the first peal of thunder being heard five minutes later. The wind held up from the northeast and east.

September 16, the rain continued throughout the day.

September 17, rain continued throughout the day, with southeast changing to northeast winds.

September 18, the day opened with a light rain. A heavy wind from the east continued throughout the day but the barometer fluctuations were not more than normal. The wind maintained a sustained velocity of 25 miles per hour from the east and northeast, with a maximum velocity of 30 miles from the east at 10 A.M. The barge "Orient" with coal from New Orleans, had her anchor chain broken and was cast on shore west of the south jetty "between 5 and 7 miles from land." All hands were lost when the ship was sunk. The following is quoted from the journal:

"The excitement of the people was very great, as most of them remembered the great storm of September 1875 and feared a repetition of the same. Everything possible was done by myself and assistant to allay their fears. The telephone was in constant demand from early morning until midnight and one man had to attend to it exclusively. The sea, as in all easterly winds, was very rough and high.

September 19. "The storm of yesterday continued with unabated fury all through the night, the wind blowing a gale from the east and the rain falling in torrents.

"The wild appearance of the sky and the fury of the winds and the continued rainfall still keep the people of the city in great dread of a repetition of the great and much dreaded storm of 1875."

This was the hurricane of September 17-22, 1885, which originated in latitude 22° north and longitude 96° west. This hurricane paralleled the Gulf coast from its point of origin, the

center passing within 50 miles of Galveston, crossing the tip of the Mississippi delta and entering on the coast of Florida about 85½° west and 30° north. The entire eastern and northern Gulf coasts from Mexico to Florida, were swept by this storm.

On June 13, 1886, the barometer commenced falling, with fresh to high easterly winds.

On June 14, the gale continued to increase in force until it reached its maximum velocity of 50 miles from the northeast at 5:50 A.M. and again 50 miles from the north at 8:05 and 8:40 A.M., from which time it gradually subsided and at 7:05 P.M. only blew at 4 miles from the west. The gale ended at 2:40 P.M. During the night the water in the bay and Gulf had risen to an alarming extent and at 7:30 in the morning the tide stood at 17.4 feet at the wharf. The eastern and western portions of the city were flooded, several bath houses, two saloons and restaurant and one dwelling house on the Gulf beach were demolished and the tracks of the Street Car Company and Texas-Mexican Railway Company on the beach front were undermined and twisted out of shape. On the bay on the north side the wharves were broken up and a number of skiffs and smaller yachts and vessels were either entirely lost or badly damaged. The weather bureau records bear this entry:

"The office was thronged with people of all classes, merchants, sea-faring men, mechanics and others; all anxiously inquiring as to the probable duration of the hurricane and the prospects of a severe overflow. The telephone also was in almost constant use."

August 19, 1886, there was a considerable decrease in pressure and lightning was observed in the east, south and southeast from 9:10 P.M. August 18, into the night. A gale set in from the east at 2:10 P.M. and attained a maximum velocity for the day of 30 miles from the northeast at 10:40 P.M. A light rain set in at 10:25 P.M. and the schooner "Livonia Perkins", 40 tons, capsized at 9 P.M., drowning the captain and three seamen.

August 20, the journal entry is as follows: "The gale of yesterday kept increasing in force, attaining its maximum velocity of 53 miles from the northeast at 6:40 A.M. and ended at 10:45 P.M. The gale caused very high water in the bay and Gulf which overflowed the town in many places to a depth of 4 and 5 feet. The current came in brisk and strong, washing away many houses, street railway and steam railway tracks, fences, etc., doing damage to the extent of $150,000.00. The wind veering to southeast and south tended to subside the agitated waters very much and those whose houses had not blown down or washed away returned to them for the night, many first obtaining the opinion of the observer that the storm was passed and would not return. A small amount of damage was done goods in the stores from the influx of water."

This was the hurricane of August 19-20, 1886, which originated in the vicinity of latitude 26° north and longitude 92° west. This point is about in the center of the Gulf. The storm passed directly northwestward and the center passed over or very near the City of Galveston. Records of the signal service for this year contain the following report of this storm, which was

sent in by the Galveston observer:

"The Texas storm which prevailed here during the night of the 19th and morning of the 20th was even more destructive to life and property than the noted storms of 1867 and 1875. During the 19th the barometer fell quite rapidly but did not get dangerously low, standing at 29.78 at 10 P.M. The lowest noted during the storm was at 7 A.M. of the 20th, when it was 29.67, at which time it began rising and went up even more rapidly than it fell.

"On the 19th the wind was from the northeast and east, attaining a storm velocity of 27 miles at 2:10 P.M., then lulling awhile, it again set in with renewed violence, attaining a maximum velocity of 53 miles from the northeast at 6:40 A.M. on the 20th. The wind of the 19th caused the waters of the Gulf to become very high, and the cars of the street railroads stopped running at 7 P.M. The water continued to increase in depth, reaching its maximum, 4 to 6 feet, at 7 A.M. on the 20th, and remained nearly stationary until 9 A.M. when it gradually subsided. Daylight found the water running in streams across the island from the Gulf of Mexico to Galveston Bay, carrying with it the debris of fences, houses, trees, clothing, furniture, etc. During the storm more than 160 houses were more or less damaged, some were carried away; a large building used as a skating rink was demolished as were also the surf bath houses, the Mexican Cable Company's building and a large building called the pagoda. The Texas-Mexican and City street railway lines were badly damaged. The tracks of the Santa Fe and M.P., railways were washed out at their approaches

to the bridge and on the mainland several miles of track were washed out or otherwise badly damaged."

This hurricane again destroyed Indianola on the lower coast and the town was abandoned.

On October 12, 1886, a gale set in from the north at 1 P.M., which continued to increase in force with a steady fall of the barometer, which reached its lowest at 10 P.M., when it registered 29.348. The maximum wind was 55 miles per hour from the northwest at 10:15 P.M. The journal states: "During the day, especially during the afternoon and up to 11 o'clock at night the office was crowded with wholesale merchants, bankers, real estate owners, mechanics and tradesmen of all classes, shipping men and sea captains, etc., all anxious to learn the latest from Washington and to get the observer's opinion as to the probable duration of the storm, the prospects of an overflow, the probable force the wind would attain and all the various questions that an excited, curious and anxious crowd could ask.

"One great cause of anxiety was the continued high water despite the strong north and northwest winds which were blowing at the time. Since the June storm and high water, and the overflow of August the people have been much agitated. The only damage done here today was to the lesser shipping, several vessels being grounded."

This was the hurricane of October 8-13, 1886, which had its point of origin in latitude 22° North and longitude west 83°. This is

at a point directly south of the western end of Cuba and the hurricane followed a path northward, crossing Cuba and then veering north, northwest then northwest- and westward until it entered the coast at a point very close to Port Arthur. It is a coincidence that the hurricane of October 8-13, 1882, had its origin in this same latitude and longitude.

June 13, 1887, a gale set in from the east at 10:10 A.M. and ended at 3 P.M. The continued high east winds threatened another overflow, causing a high tide on the beach.

September 18, 1887, northeast storm warnings were received at 9:30 P.M., and on the following day a gale commenced at 10:18 A.M. from the northeast, attaining a maximum velocity of 36 miles per hour from the northeast at 9 P.M. The gale continued into the night and at 5:10 A.M. and again at 7:30 A.M. on the morning of the 20th attained a maximum velocity of 40 miles from the northeast. The gale continued throughout the day and caused considerable alarm among the people as to the prospects of an overflow.

This was the hurricane of September 11-22, and had its origin in latitude 14° north and longitude 59° west. It followed the usual hurricane path from the Windward Islands south of the Islands of Porto Rico, San Domingo, Jamaica, veering slightly southward and turning northwestward at a point off the coast of Honduras. It crossed the tip of Yucatan and headed in a direct line for Port Arthur suddenly turning westward and entering the lower Texas coast. The center of this hurricane, at its closest, was about 175 miles from Galveston.

October 17, 1877, an unusually high tide was reported on the Gulf front which caused considerable apprehension as to an overflow. The tide washed away the break-water and street car tracks.

On October 18, a gale began from the northeast at 4:20 A.M. and attained a maximum velocity of 32 miles from the northeast. The wind continued to increase in force, attaining a maximum of 48 miles from the north at 5 P.M. During the height of the wind the barge "Lark" of the Houston Direct Navigation Company sank.

This was the hurricane of October 11-20, 1887, which originated in the vicinity of 16° north latitude and 75° west longitude, which is a point directly south of the Island of Jamaica. The hurricane traveled northwestward, passing through the Yucatan channel, thence westward to a point a few miles off of the extreme Southern Texas Coast. The hurricane then changed its course to northward and then northeastward, paralleling the Texas Coast to its eastern extremity with the center of the hurricane maintaining an average distance of from 25 to 50 miles from the shore. It passed inland about the mouth of the Sabine River and followed the Gulf shore, crossing the northern portion of Florida and entering the Atlantic Ocean.

June 17, 1888, a hurricane visited the vicinity of Galveston, causing a maximum wind velocity of 54 miles from the southeast, an unusually high tide and destroying the bath houses on the Gulf front.

July 5, 1888, the journal contains the following entry: "The morning opens with cloudy and threatening weather and fresh easterly wind. The waters of the Gulf are in a great turmoil and the tide is unusually high. The surface of the water about a mile from shore is hidden by misty vapors. The wind increased to high at 1 P.M. and so continued until 5:25 P.M. It blew in gusts and was attended by rain squalls which began at 1 P.M. and continued until after midnight. The maximum velocity of the wind was 42 miles from the east at 4:58 P.M. Lightning was observed in the north during the evening, when the wind suddenly veered from south-east to south blowing fresh." While this description is typical of a hurricane the duration of the conditions was so short that it can hardly be classed as a hurricane. It appears to have been a strong "low" passing in from the Gulf, although it might have been a hurricane which had its point of origin in the Gulf a short distance from Galveston.

On August 18 and 19, 1888, Galveston was slightly affected by the hurricane of August 16-20, 1888, which had its point of origin near latitude 26° north and longitude 78° west.

This hurricane moved from its point of origin east of the southern coast of Florida across the tip of Southern Florida in a direct line toward a point close to Galveston. After passing the Mississippi delta the storm curved northwestward, entering the Louisiana coast about midway between Port Arthur and New Orleans.

The hurricane of September 1-10, 1888, also slightly affected Galveston, although its center was never closer than 700

miles to the city.

This hurricane originated to the east of the West Indies and passing westward above Porto Rico and San Domingo, crossed the Island of Cuba and the Peninsula of Yucatan and passed into lower Mexico. Galveston had brisk to fresh northeast winds dating from the 2nd to the 7th, with high tide, tempestous sea and typical indications of an approaching tropical hurricane.

During the period from October 22 to 25, 1888, Galveston experienced strong northeast winds with a maximum velocity of 40 miles per hour, rain and high tide. It is evident that this was a "low" passing into the Texas Coast from the Gulf, as the winds on October 25th changed from fresh east to fresh southeast and the stormy conditions diminished. However, this and the following storm may have been a hurricane passing inland at a point considerably below Galveston.

The same is true of the period from August 7 to 10 inclusive, 1889, when the city experienced brisk northeast winds for a period of three days, the maximum velocity reaching 44 miles per hour from the northeast when they suddenly veered to the south.

The hurricane of September 15-24, 1889, whose center passed about 300 miles out in the Gulf, caused high northeast winds and rising tide at Galveston.

August 30, 1890, three well defined waterspouts were observed at 6:15 P.M. in the Gulf about one and one-half miles off the south coast of the island. These waterspouts were visible for about 30 minutes but passing northeastward did not reach the city.

June 17, 1891 a waterspout was reported as occurring in the Gulf southwest of the city about 5 o'clock. It lasted about 15 minutes and passing northeastward did not touch the city.

July 3, 1891, fresh to brisk easterly winds were reported with light rain and fresh to brisk east winds on the following day.

On July 5th a "tidal wave" came in the city in low places early in the morning and did damage to the extent of about $2,000.00. The barometer at 8 A.M. read 29.78 and the wind reached a velocity of 40 miles from the northeast at 7:50 A.M. and a maximum velocity of 60 miles per hour from the northeast at 9 P.M. At 9:30 P.M. the barometer registered 29.24 when the wind suddenly shifted to southeast and then southwest. During the height of the storm a fishing vessel was sunk in the harbor and a boy and four of the crew were drowned.

November 6, 1892, a tornado struck the Island 10 miles down the coast and lasted from 5:45 until 6:30 A.M. It did considerable damage, demolishing houses, barns and destroying crops and killing live stock, but traversing a farming district the value of the damage was not great.

August 13, 1893, several waterspouts were observed in the bay three miles north of the city. They lasted from 12:15 to 12:25 but did no damage.

October 3, 1894, a waterspout was reported in the east bay about 5 miles from Bolivar Point between 10 and 11 A.M. It is estimated that the column of water which composed the spout was not less than 200 feet in diameter at the base and approximately

1000 feet in height.

October 4, 1894, a waterspout was reported about 12 o'clock noon about 6 miles south of the city.

October 5, 1894, fresh to brisk northeast winds were reported, with the sea roughing up considerably in the afternoon.

October 6, the wind was brisk from the east with a high tide in the morning and a very rough sea. The high tide continued with heavy swells during the night.

October 7, a light to high northerly wind was recorded with an unusually high tide in the morning coming into the sewers on the south side of the city. Besides the high tide, during the day there were at intervals of half an hour or more exceptionally large swells in the Gulf, which were perhaps three feet higher than the average swells which had been very large during the day. These conditions probably were caused by the hurricane of October 3-9, 1894, which had its origin in the vicinity of 17° north, 82° west. This hurricane passed from the Caribbean into the Gulf through the Yucatan Channel and veering northward and northeastward passed into the northern part of Florida.

August 28, 1895, fresh to brisk easterly winds were reported, with a heavy sea observed at night which indicated a hurricane in the Gulf.

August 29, the brisk to high easterly winds increased to storm velocity and while the barometer remained stationary conditions continued threatening throughout the day and the swells from the Gulf increased. The swells at 8 A.M. were the highest

since July 5, 1891, but no material damage resulted. There was slight erosion of the beach and some jetty piling washed away. Hurricane rockets were fired and hurricane warnings issued, but the conditions gradually subsided the following day.

This was the hurricane of August 24-29, 1895, which had its point of origin at 14° north and 70° west. It passed in a west-northwesterly direction, touching the tip of the Yucatan Peninsula and passing inland on the lower Texas Coast. The center missed Galveston by about 75 miles.

August 11, 1896, a waterspout was observed about 4 miles northwest of the station at 8:38 P.M.

September 20, 1896, two waterspouts were observed in the Gulf 4 miles east at 12 noon. They lasted about 8 minutes. On the same day others were reported from various points in the vicinity of Galveston and another was observed 5 miles to the southwest at 7:20 P.M. This last one lasted 10 minutes.

From November 22 to 25 inclusive, strong easterly becoming southeasterly winds brought in an unusually high tide which reached its maximum at about 11:30 P.M. on the 25th, when it entered the sewers on the south side of the city. The tide was highest in more than a year, but no material damage was done.

August 14, 1898, a well defined waterspout was observed at 6:55 A.M. in the Gulf about 5 miles southeast of Galveston. It moved north by east and was visible for about 22 minutes.

From September 18 to 30, inclusive, 1899, Galveston experienced easterly and northeasterly winds with a gale of 26 miles from the

northeast at 12:55 P.M. on the 19th, which caused a very high tide and rough sea. Heavy swells were observed at intervals of from three to six minutes bearing from the south-southeast, which came in over the low places on the south side of the city and reached their maximum about 9 A.M. During the interval between the 20th and 24th variable winds were encountered when they again set in strong from the east. On the 28th the wind freshened to a gale from the northeast. The sea was very rough and the tide was unusually high in the afternoon and evening, coming up into the low places in the southern part of the city. Strong swells were observed at intervals of about 15 minutes. These conditions continued over night and through the 29th and 30th the tide remained high with irregular heavy swells bearing from the south-southeast. Evidently these conditions were caused by two hurricanes following close upon one another, whose centers were several hundred miles to the south-southeast of Galveston.

From July 10 to 13 inclusive, in 1900, the year of the big storm, fresh to brisk easterly winds were experienced at Galveston, with a rough sea, heavy southeast swells and a high tide, which was apparently higher than at any time in a good many years. During the night the tracks of the city street railway were damaged to the extent of $1,000.00.

On September 8, 1900, occurred the disastrous storm at Galveston ~~which~~ that will go down in history.

This was the hurricane of September 1-10 which originated

near latitude 15° north, longitude 65° west and traveled westward and northwestward to a point south of Cuba in line with Florida. Thence it passed directly northward until crossing the Florida Keys, it veered northwestward and west by north and entered the Texas Coast at a point just above Galveston. About $30,000,000.00 worth of damage was done to the City of Galveston and immediate vicinity and the loss of life is variously estimated at from eight to fourteen thousand persons.

May 21, 1901, several waterspouts were observed in the bay and Gulf and a house on the west end of the island was reported to have been struck and nearly demolished by one.

The hurricane of September 12-18, 1901, which originated in latitude 18° north, longitude 69° west, caused a high tide and considerable anxiety at Galveston. This hurricane crossed portions of the islands of San Domingo and Cuba and went into the central Gulf where it followed a course which would have carried it near New Orleans, At a point below the Mississippi delta it suddenly curved northeastward and passed inland in the northern portion of Florida. The center of this hurricane at no time was nearer than 300 miles to Galveston, yet it caused an unusually high tide and threatening conditions.

The weather journal entry of September 16, bears the following: "Little work was done in the office today except to answer telephone calls and assure visitors that the town was not going to be washed away. The threatening conditions continued to increase and during the early evening of the 18th an unusually

high tide was noted and heavy swells set in from the southeast."

July 20, 1902, a waterspout was observed in the bay from 11:20 to 11:26, which caused considerable alarm to occupants of fishing and small craft in the bay.

July 26, 1902, two waterspouts were observed in the Gulf in the afternoon.

July 21, 1909, a tropical hurricane of severe intensity passed inland on the Texas coast killing 41 people and doing an estimated damage of $2,000,000.00. This is the hurricane of July 18-22, which was first observed on the morning of July 18, apparently central over Western Cuba. It moved in a northwesterly direction into the Gulf of Mexico and approached the Texas coast at a rate of about 10 miles per hour. At 7 A.M., July 21 its center was located about 30 miles southeast of Galveston. During the forenoon it moved inland, its center passing over Velasco, where a calm of 45 minutes was reported with a clearing sky. On the following day the hurricane broke up in southwest Texas in the vicinity of Del Rio.

The destruction by wind and wave on the coast was considerable; the destructive force of the wind diminishing as the hurricane moved inland.

With particular reference to Galveston, Dr. Bernard Bunnemeyer, then in charge of the Galveston office of the United States Weather Bureau, reported to the Chief of the Weather Bureau: "The tropical storm of July 21, 1909, from a commercial as well as residential point of view has proven of the utmost importance

to the city of Galveston. It was a very satisfactory test of the protection of the sea wall which was built after the destructive hurricane of 1900. Not a single life was lost within the protected area and the damage to property was only nominal, consisting principally of broken trees, fences and windows, and other minor losses. Outside of the sea wall everything exposed to the wind and waves was either destroyed or suffered severely. Among the property completely lost were two bathing pavilions, two fishing piers leading out from the sea wall, several structures near the beach beyond the western terminus of the sea wall, and two fishing piers on the jetties several miles east of Galveston. One other bathing pavillion was badly damaged.

"The railroad bridge over the bay suffered to some extent, and traffic as well as telegraphic and telephonic communication was interrupted. Washouts occurred in several places. The total damage is estimated at $100,000.00 and may possibly be greater.

"The two fishing piers on the jetties were occupied on the day of the storm. The occupants of one of these piers were taken off before it was demolished; those of the other pier, consisting of 11 persons, went down with the structure, not, however, until after several heroic efforts had been made to save them. Seven of the 11 occupants were picked up alive on the following day by searching parties at a distance of 25 miles from the pier; three were picked up dead, and one is still unaccounted for and probably lost.

"There was no damage to shipping, except that a few small boats were lost. The sloop "Ellen," a fishing boat, was towed into port after the storm, with masts and rigging gone. Her captain, who was in a small boat at the time, was lost, struck by the boom during a gust of wind, as he was trying to board his sloop. He was probably instantly killed. The situation may be summed up as follows: Four persons dead and one person unaccounted for, property loss about $100,000, nearly all of which occurred outside of the sea wall.

"The first announcement of the approach of this storm was received at this office at 12:57 P.M., July 18, 1909, the advisory message coming from Washington through New Orleans. This was followed by further advisory messages received 1:05 P.M., July 19, and 9:45 A.M., July 20, the last message being to the effect that the disturbance was apparently over the central Gulf moving northward. Shipping interests and the public were kept thoroughly posted by telephone, bulletins and the press, and I do not believe that on July 20 there was a single news-reading person in the city who was not aware of this storm. The weather was fine on July 19, and the sunset of that day was beautiful, showing in succession nearly all the colors of the rainbow over the greater portion of the sky. The 20th, which was the day before the storm, opened clear. Toward noon a cirrus haze began to overspread the sky, which became slowly denser during the afternoon and gradually merged into alto-stratus clouds. By nightfall the sky was overcast, but later cleared, with clouds remaining in

the eastern horizon. The wind was light until 7:00 P.M., when it shifted to the northeast, increasing in force and coming in mild gusts. At 8:40 P.M., the wind became north, but continued gusty. The highest velocity to midnight was 26 miles. There was a heavy sea swell and the Gulf was unusually high.

"The wind continued north throughout the night and until 8:40 A.M., July 21, when it became northeast, gaining steadily in force with frequent violent gusts. Immediately after the morning observation, at 7:15 A.M., storm warnings were displayed, but the halyards parted at about 9:00 A.M., from the immense strain to which they were subjected. At 10:25 A.M., the wind shifted to the east, and at 10:50 A.M., attained a velocity of 68 miles per hour for five minutes. During this high velocity a gust of one minute's duration occurred at the rate of 78 miles per hour. At 11:40 A.M., the wind became southeast and continued in that quadrant until after the storm. At 11:45 A.M., one of the wires connecting with the anemometer snapped at the binding post and for 12½ minutes there was a blank in the wind record. The anemometer, however, showed that during this period the wind traveled fourteen miles. At about 12:35 P.M., there was a marked decrease in the violence of the wind and from this time on it lessened steadily but slowly. At 2:00 P.M., the wind record was again broken, but this time it was found to be due to the mechanism of the anemometer dial, and the extra anemometer was substituted, which cured the defective record.

"During the day the sky was covered with low stratus clouds and scud which moved rapidly with the surface wind. Rain occurred from 5:11 A.M., to 5:28 A.M., and from 5:45 A.M., to 12:40 P.M., but most of the time it was a very light driving drizzle. The total precipitation for the day was 0.50 inch. It is my opinion that much of this drizzle was spray driven in from the Gulf. It was subsequently found that nearly all trees and shrubbery, except palms, withered on the windward side, the leaves appearing scorched as by a fire and dropping off. It is believed that this phenomenon was caused by the action of salt water carried inland by the wind.

"The lowest pressure was 29.557 inches at 10:05 A.M. From the direction of the wind, which was successively N., NE., E., and S.E., it appears that the center of the storm passed south of Galveston. Press dispatches later had it that there were two storms at Velasco, Brazoria County, and at Bay City, Matagorda County; the first coming from the north and the second from the south. This indicates that the storm center moved inland over Velasco and Bay City, and that it passed about 25 miles south of Galveston.

"The Gulf, it is estimated, rose to a height of nearly 10 feet above the normal and the entire western portion of Galveston Island was under water, drowning a number of cattle and hogs. Volumes of water dashed over the sea wall and flooded successively the lower portions of the city. It was 2:00 P.M.,

before this water finally disappeared through the drainage pipes.

"The local office of the Weather Bureau was besieged by anxious inquirers during the entire day. From 4:00 A.M., until 7:00 A.M., Messrs. Scott and Martin answered all telephone calls, and after 7:00 A.M., Mr. W. P. Stewart (now in charge of the Galveston office) was kept constantly busy at the telephone, advising people in the threatened sections to move into town to safer places, and that no assurance could be given until after the barometer should begin to rise. Thousands of people came down town and sought refuge in the county court house, public library, hotels and office buildings, the police and fire departments assisting in conveying them to safety. Our own office building was crowded from top to bottom. During the height of the storm the largest office window was blown in, the thermograph upset, and the station maximum thermometer broken."

It is peculiar to note that when Professor O. L. Fassig was compiling data for the bulletin, "Hurricanes of the West Indies," the hurricane of July 18-22, 1909 was omitted. It is understood because no Weather Bureau reporting station registered a hurricane barometer.

The August 16 hurricane, 1915, is so well known and so fresh in our memory that a description of it hardly need be given here. This hurricane was probably of greater force than the hurricane of September 1-10, 1900. It had a wider area, a higher wind velocity and its passage inland covered a much longer period. The accompanying tide is reported to have been

higher than in the 1900 storm, and it is evident that if Galveston had not been protected by its seawall the loss of life and damage to the city would have been equal, if not greater than in the 1900 hurricane.

This hurricane was first observed on the morning of August 10 between the Windward Islands of Barbados and Dominica. On the morning of August 11 the hurricane was apparently near and south of the Island of St. Croix. On the morning of August 12 the hurricane was central a short distance south of Haiti. At noon of the 12th observations indicated that the hurricane was central near the east coast of Jamaica and during the night the hurricane passed north of the Island of Jamaica.

On the morning of the 14th the hurricane was apparently central near the Isle of Pines, Cuba, with undiminished intensity, and during the night passed through the Yucatan channel and into the Gulf of Mexico. On Sunday morning, August 15, the hurricane was apparently central in the south-central Gulf and moving in a more northwesterly direction than before.

On the morning of the 16th the hurricane was apparently central off the coast of Texas. Galveston had a barometer of 29.62 inches with a maximum wind of 34 miles per hour from the northeast. Shortly after noon the barometer had fallen to 29.48 inches and the wind had increased to a maximum velocity of 56 miles per hour, maintaining the same direction. The lower portions of the city already were flooded, and as darkness fell the wind

and height of tide increased. By 8 o'clock the barometer was 29.10 inches and the wind velocity was 72 miles per hour from the northeast. During the night the hurricane passed inland, the center apparently passing Galveston at a point estimated at from 25 to 35 miles down the coast. Shortly after 2 o'clock the barometer reached its lowest, 28.66, and the wind reached its maximum at a sustained velocity of 93 miles per hour from the east. One minute of wind was registered at a velocity of 120 miles per hour.

The estimated height of the tide was about 12 feet and all portions of the city were covered with water to a depth of from several inches to nine feet. The Galveston News, in an issue published immediately after the hurricane, stated that on some portions of Market street,--Galveston's principal business street-- the water stood at a depth of nine feet.

The city was greatly damaged by wind and water. Stocks in many business houses were ruined by water, a number of houses in the east end of the city were either demolished or washed from their foundations by water topping the sea wall, and several piers and wharves were demolished or badly damaged. Practically everything outside the protection of the sea wall was completely swept away. Shipping in the harbor was badly damaged, the causeway crossing Galveston bay was partly destroyed, and the tracks, roadbed and overhead of the Interurban from Galveston's city limits to Texas City Junction, on the mainland, were destroyed. The money value of property lost, including crops, has been var-

iously estimated at from five to sixty million dollars; and the loss of life has been estimated at from 300 to 1200. Less than half a dozen people lost their lives in the city, the majority being on dredge boats, on the western part of the island, Bolivar Peninsula and the mainland.

The hurricane lasted through the night and wind and tide did not abate until late the following day.

Following this hurricane by less than six weeks two hurricanes passed from the Caribbean into the Gulf, neither of which damaged the coast of Texas. The second hurricane, passing inland near Burrwood, Louisiana, caused slight swells in the western Gulf with a cirrus cloud formation, and strong northerly winds after it had passed inland.

Yours very truly,